DELTA LIGHT PROPAGATION VOLUMES
FOR MIXED REALITY

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Problem definition
Global Illumination between real and virtual worlds

- Mixed Reality needs proper relighting
  - Real to virtual → e.g. real light on virtual surface
  - Virtual to real → e.g. virtual lights illuminating real surfaces
  - Real to virtual to real → e.g. real light bouncing off virtual surface back on reality, real light blocked by virtual geometry casting shadows
- So far two (three) reliable real-time Global Illumination solutions
  - Differential Instant Radiosity
  - Multi-resolution splatting
  - (Irradiance Caching by Peter and Hannes)
- Temporal coherency and speed issues
The Delta Radiance Field

Theory

$L^\mu$
The Delta Radiance Field

Theory

$L^\rho$
The Delta Radiance Field

Theory

\[ L^\rho - L^\mu = \sum_{i=0}^{\infty} T^i_{\rho} L_e - \sum_{i=0}^{\infty} T^i_{\mu} L_e = \sum_{i=0}^{\infty} [T^i_{\rho} L_e - T^i_{\mu} L_e] = \sum_{i=0}^{\infty} T^i_{\Delta} L_e = L^\Delta \]
The Delta Radiance Field

Light Propagation Volumes

- **Setup**
  - Render Reflective Shadow Map
  - Create empty volume (e.g. $32^3$)

- **Injection**
  - Sample RSM, create VPLs
  - Inject SH encoded VPLs into volume

- **Propagation**
  - Distribute light from each cell to neighbors for n steps
The Delta Light Propagation Volume
Implementation of a DRF

- Given
  - Real lights, geometry & materials
  - Render RSM $R^p$ (object)
  - Render RSM $R^\mu$ (object)
  - Injection (direct + indirect)
    - Add $R^p$ to volume
    - Subtract $R^\mu$ from volume
- Proceed normally
Video available at
http://www.tobias-franke.eu/publications/franke13dlpv/
Discussion

Advantages

- **Unified corrective factor** for indirect bounces and shadows
  - Just plug over real radiance field

- Solves **temporal coherency** with brute force
  - Just inject entire RSM to DLPV

- Volumetric correction can support lightfield effects

- **Fast & GPU friendly**
  - Default solution evaluates in ~6 ms
  - Grid solution and propagation steps can be adjusted on new hardware
Discussion
Comparison with Lensing and Broll

Multi-Resolution Splatting

~4k VPLs, $d_{\text{normal}}$ 10°, $d_{\text{depth}}$ 1 cm
9.8 ms

Delta Light Propagation Volume

~262k VPLs, 32 Propagations
9.6 ms
**Discussion**

**Open issues**

- **Low spatial resolution**
  - Shadows heavily aliased
  - Bleeding artifacts
    - Visible in thin geometry
    - Wrong energy subtraction
  - Self-illumination issues
- Volume size may cut off lights and shadows
- Propagation scheme inefficient in the long run
Thank You
Source Code
http://www.tobias-franke.eu/publications/franke13dlpv/